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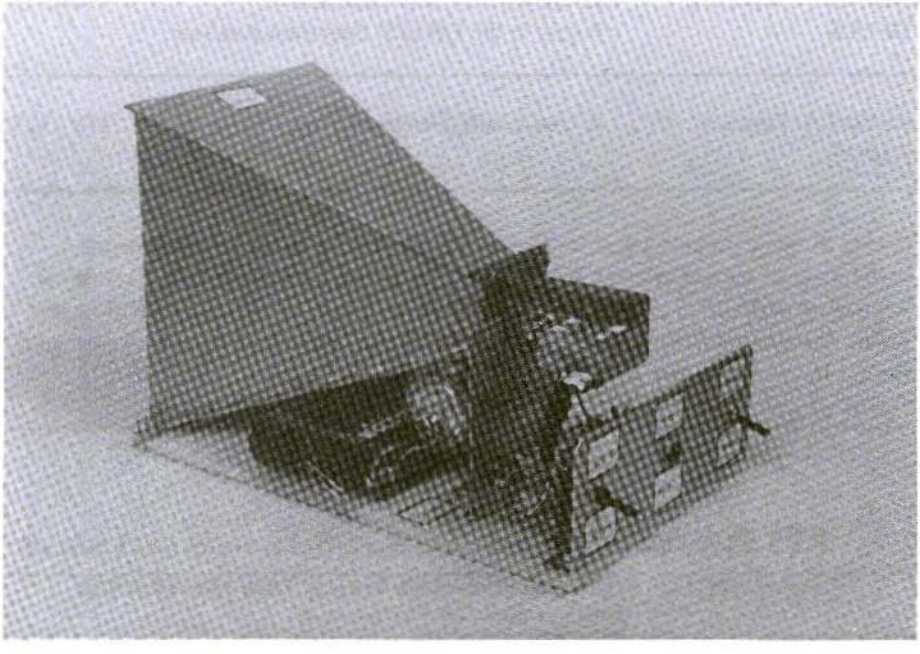
Using a DRO as a Transmitter

To receive TV satellites a low noise block (LNB) is used first to amplify the 10 to 12 GHz signal collected by a parabolic antenna. Then a local oscillator (OL) and a mixer change the signal into a lower intermediate frequency, usually between 950 and 2150 MHz. That frequency comes via a coaxial cable to a demodulator which delivers video and audio signals to the TV set.

The local oscillator is a Dielectric resonator Oscillator (DRO). As already described [1], we can make a 3 centimetres super-regenerative receiver using a DRO. We will see how to make a transmitter and try not to destroy transistors!



1. THE DRO

If recent LNBs have an integrated circuit which provides both LO and mixer, the older ones have separate circuits. A transistor is used as oscillator and diodes as mixer. That kind of LNB is the one useful for us to make RX and TX. We can obtain them from TV antenna installers [1].

The OL comprises a 10 GHz transistor, a DRO, strip-lines, resistors and capacitors on a glass-PTFE PCB. Inside the LNB, the OL is contained in a sealed can, in order to avoid any radiation from, or to, other circuits. The frequency adjustment is provided by adjustment of a screw located on the cover.

Several forms of oscillators are used, the feedback can be made by the DRO between gate and drain, gate and source, or by reflection. The output power can be drawn from the source or the drain. Figures 1 and 2 give the diagrams of common printed circuits. To make a transmitter all are usable, but that is not always the case for a super-regenerative receiver.

A 5 or 8 volts regulator supplies the transistor as well the other LNB circuits, but, a dropping resistor reduces the voltage to about 3 volts at app. 15 to 30 mA. The RF power is around 20 mW (= 13 dBm).

As the OL frequency is not suitable for amateur band use, we have to modify it. As shown in [1], it is better to have a lower frequency DR as required which is about 10.368 GHz.

The 9.75 and 10 GHz OL (Astra satellite) are preferred instead of the 11.475 GHz ones, as it is easier to increase the DR frequency by height reduction rather than to lower it by adding chips of ceramic.

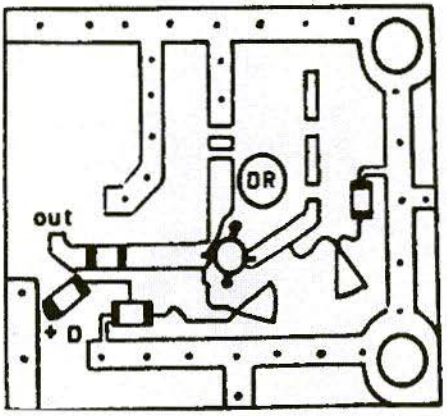


Fig.1: PCB of a DRO Gate/Drain Feedback Source O/P Dimensions: 25 x 30mm

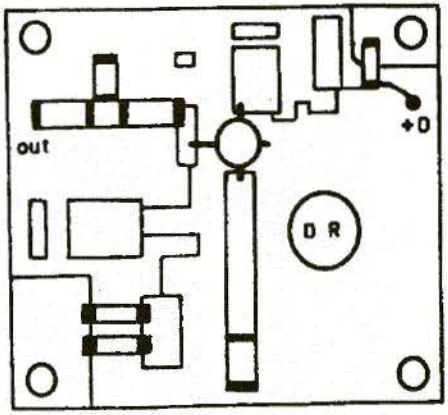


Fig.2: PCB of a DRO Earthed Drain, Gate Reflection, Source O/P Dimensions: 25 x 30mm

2.
DRO EXTRACTION FROM AN LNB

First of all open the LNB by removing screws or rivets which fasten the external enclosure. Then find the DRO, that is easy thanks to the frequency adjustment screw and remove the small cover which holds that screw.

Then feed the LNB at its nominal voltage, around 12 volts. Check the DRO drain voltage, nearly 3 volts. Calculate the current by measuring the voltage drop on the drain or source resistor according to the case. Note those values as they will be used in our transmitter.

To be sure that the circuit is oscillating put back the cover, because some DRO do not oscillate, or oscillate badly without it. The oscillation is present if a drain current variation is shown when you finger the DRO output driving the mixer. When we are sure of the operation we need to extract it from the LNB enclosure. A saw will be used to cut the aluminium and scissors for the PCB, in order to extract the useful section, which is limited to the OL output. Beware of mechanical shocks to avoid cracking, breaking or ungluing the DR. If it is cracked it will work but less satisfactory. Unglued it would be difficult to bring back to the right place.

We have now a small closed block with only one aperture clearing the PCB where the line was going to the mixer.

3.
TEST OF THE DRO ALONE

That small block no longer has connections to feed the drain, it is now time to discover a real way to kill transistors!

As the drain-source voltage required is around 3 volts, we can think that two 1.5 Volt batteries will do the job, very convenient for a portable TX, or for indoor tests with a regulated power supply of that voltage: beware "danger".

Everyone knows or must knows that the more efficient high frequency active components as MOS, GaAsFET, HEMT are very sensitive to electrostatic discharges so there need a lot of care for storage, handling and mounting. So grounded conductive wrist strap, soldering iron uncoupled from the mains, no synthetic material clothes, antistatic cover on the working table, etc.

Another kind of breakdown caused the destruction of a dozen of 10 to 24 GHz transistors because no information was available to me: one must not allow fast variations (high dv//dt) in supply voltages, for these kind of components.

If 3 volts or more is applied abruptly to the drain, you run a risk of breaking the transistor between drain and source. If you vary the drain resistor by a decade resistor, at the time of transit between contacts: beware. Likewise if you vary the decoupling capacitor between drain and ground by a decade capacitor. A short-circuit between drain and ground: breakdown, not the power supply , if it is protected, but the transistor. If a modulation signal is applied to the gate, the source or the drain, beware also if the voltage is too high or the reverse and if a high dv/dt occurs.

So respect these rules:

- maintain a resistor in the drain supply that will damp the dv/dt owing to the decoupling capacitor. So a higher starting voltage must be delivered from a 5 or 8 Volt regulator

- not to make the dangerous manoeuvres as above mentioned

if you do not want to see the current drain going to up to 50 mA or more that surely means the transistor is destroyed.

If the price of this kind of transistor is not very high, soldering and unsoldering especially is so delicate you would be better to avoid them.

4. DRO FREQUENCY MODIFICATION

First we need a means to measure the frequency, so we have a 10 GHz frequency meter. The easiest and cheapest way is to use a new LNB, or a working second hand, having a 9.75 GHz OL and a 1 GHz frequency meter, as one made from these available inexpensive kits. The DRO radiation will be received by the LNB and we will have:

frequency DRO =
9.75 GHz + frequency meter reading.

So we will read 618 MHz for a 10.368 GHz DRO.

It is obvious than the frequency meter will indicate zero if the tested DRO frequency is 9.75 GHz also. A reading will only appear when we increase the frequency enough.

To move the DRO frequency from 9.75 to 10.368 GHz, needs to reduce the DR height. Articles [1] and [2] explain that

operation can be done by sand-paper. That means to unglue the DR from the PCB with the risk to crack or to break it. Furthermore it requires to bring it back to the right place. It is better to keep it in position and to abrade it with a small millstone powered by a miniature electric motor.

The abrasion is more or less fast according to hardness of the DR ceramic. It seems that light yellow DR having a hole inside are easier to abrade than those made with white ceramic ones. As the ceramic dust could be toxic, do not breath it when abrading.

It is essential to check the height reduction by measuring the frequency frequently in order not to exceed the requisite value.

Frequency measurements must be done with the cover in position and the screw at half turn to obtain a sufficient adjustment range. If the screw is too close to the DR to obtain the required frequency, a power loss is caused by an oscillating circuit overdamping. On the other hand, if the screw is to far from the DR the adjustment range can be lower to compensate for the DRO-waveguide coupling effect.

If LNB's having a 9.75 or 10 GHz DRO are not available, but only those very common types having a 11.475 GHz one, you need to lower the frequency by increasing the DRO height. That can be done by fixing with an ultra-fast glue a small chip taken from an another DR which is sacrificed for that. The use of ceramic coming from capacitors or other kind of component is more uncertain. If the ceramic has a high permittivity it has a high temperature coefficient generally that will be disastrous for our transmitter stability. If the permittivity is low, the temperature coefficient will be low generally, but it will be necessary to add a large piece of ceramic and that will create other difficulties, for instance, the screw could be in contact with the DR as soon as it is moved.

As pointed out in [1], it is advisable to make an ageing cycle on the DRO modified in order to remove any mechanical stress due to handling.

5. DRO MODULATION

If it is difficult to get the bandwidth for TV [2], but telephony, even wide FM, only requires 50 to 200 kHz. That is easily obtained by applying the modulation to the drain supply. That is done here by audio signal injection into the normally grounded pin of the voltage regulator by means of a resistor. So the DC voltage is modulated with a variation of 100 to 300 mV peak to peak.

In order to make easier low signal finding, a 1000 Hz square-wave modulation is provided by a 555. For voice, an electret mike and a 741 amplifier give an almost equal voltage to the 1000 Hz one, therefore getting the same modulation swing.

The circuit diagram of the transmitter is shown in figure 3.

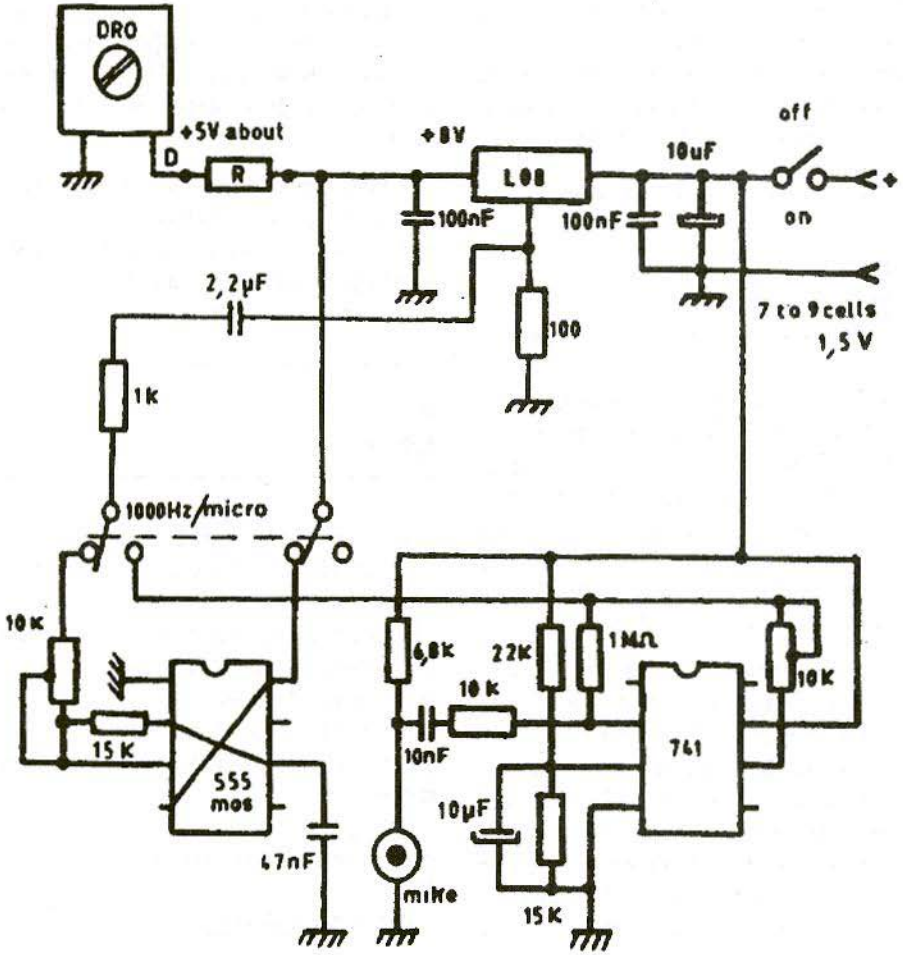


Fig.3: Circuit Diagram of the DRO Transmitter

6. MECHANICAL ASSEMBLY

The DRO must be joined to an antenna and it is very simple to make a 20 dB horn as described in the article [4] with gives dimensions and method of construction. Using copper-clad glass-epoxy for PCB makes it quite easy.

A WR90/R100 waveguide brings the HF to the horn. A slot into the waveguide lets in a probe to inject the 10 GHz. The DRO is placed against the waveguide with slides in order to fix the probe at the optimum place giving the highest radiated power. Two setting screws are provided for impedance matching between DRO and waveguide so as to improve the transfer efficiency.

The complete horn, waveguide, DRO, supply and modulation circuits are mounted on a plate as shown in the photograph. Figure 5 gives the mechanical assembly of the 10 GHz parts.

7. TESTING AND ADJUSTMENT

Once the assembly is completed, we need to check the output voltage regulator, DRO drain current, 1000 Hz voltage and frequency, voltage and waveforms from the microphone amplifier. Resistor R in figure 4 will be chosen in order to obtain the same DRO voltage and current as the original values.

Then, we need to obtain the highest radiated power. To do that, we have to make a field-strength-meter with a horn, waveguide, SHF diode and a micro-ammeter, as described in [5] and [6]. The distance between the TX and that f.s.m. will be around one meter, in order to obtain a meaningful reading, but not to have direct coupling between them. We have to play with the probe fitted in the slot and the two impedance matching screws. Settings are interdependent and we have to act minutely and methodically to get the optimum result. We also have to retune using the frequency screw, as the frequency must remain at the required value because the above adjustments are affecting it. If a frequency analyser is available, we can check the unmodulated wave purity and the 1000 Hz and microphone swings. Otherwise, we can listen the TX to check its quality. The receiver could be a super-regenerative one such as described in [1] or an LNB as used for frequency measurement, followed in this case, by a 600 MHz receiver as a scanner.

Warning: even the radiated power (erp) is modest (1 to 2 watts), so DO NOT look inside the horn when the TX is working, because the human retina is very sensitive to SHF.

8. QSO

As already quoted in [1], this kind of TX has already allowed (the time this article was written), QSOs up to 48 kilometres line-of-sight. It is foreseeable to get much longer distances and also by reflection, refraction or scattering as obtained by other TX. We can use a parabolic dish to increase the radiated power.

9. CONCLUSIONS

It is very instructive to work at 10 GHz with very simple and cheap means, owing to the experience and experiments we can do during realisation and adjustment, as well as making QSOs: difficulties due to components miniaturisation, settings interdependence on the one hand, and propagation irregularities even in sight due to the clouds, rain and fog, on the other hand.

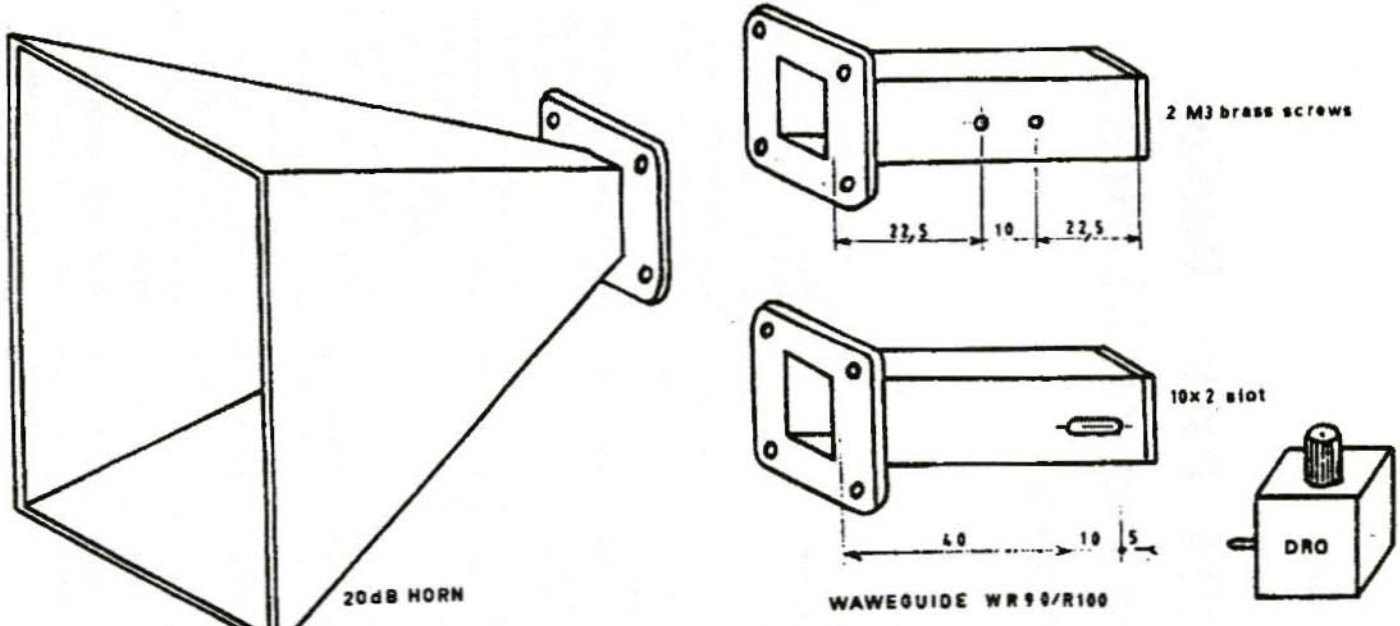


Fig.4: Mechanical Design including Waveguide Front and Rear Views